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ABSTRACT

Because human memory and thought involve extremely complex processes, it is possible to employ unusual modalities and specific visual strategies for remembering and problem-solving to assist patients with memory defects. This three-part paper discusses some of the research in the field of human memory and describes practical applications of these research findings. Part one reviews the experience of the memory consultation service at the Neurological Institute of New York and demonstrates that human memory is a process dependent on duration, modality, and lesion localization. Part two discusses ancient and modern mnemonic systems and how such systems can be used to bypass specific functional defects in order to improve modality specific memory disorders. Part three describes how Albert Einstein used visual methods of thinking to overcome deficiencies in verbal learning. (HAI)

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MENTAL IMAGES AND THE MODIFICATION OF LEARNING DEFECTS

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Introduction

This paper is divided into three parts. Part one reviews the experience of the memory consultation service at the Neurological Institute of New York and demonstrates that human memory is a complex process which is duration, modality, and lesion localization dependent. Part two discusses mnemonic systems both ancient and modern and discusses how such systems can be used to bypass specific functional defects to improve modality specific memory disorders. Finally, Part three presents the case of Albert Einstein and how he used visual methods of thinking to overcome deficiencies in verbal learning.

Part I. Modality Specific Memory Disorders in Man

Modality specific memory disorders have been produced in the octopus by selective oblation experiments (1.). Removal, for instance, of the optic lobe results in marked impairment of visual memory and learning with preservation of tactile memory. Removal of posterior buccal lobe produces marked impairment of tactile memory whereas visual memory remains intact. The existence of such regional specialization of memory in the brain of this form of life has raised questions about similar specialization of memory function in the brain of man. Remarkable differences do exist in the ability of Korsakoff patients to learn motor and kinesthetic tasks while they are unable to remember any visual or verbal material, suggesting a separate center exists for motor or kinesthetic memory (2.); Brenda Milner's (2.) work indicates that dominant hemisphere lesions tend to impair verbal memory and learning, whereas non-dominant hemisphere lesions tend to impair non-verbal learning and memory. Similar results, differing only in details have been reported by others (3.).

The purpose of this part is to illustrate how the pattern distribution of modality specific memory defects depends on the location of the site of pathology.

Material and Methods

General Evaluation: In July 1970 a special consultation service for patients with memory defects was established at the Neurological Institute of New York. All of the patients reported here were specifically referred to that service by their ward or private physician. Each patient, of course, received a detailed

history and physical exam by at least one resident and an attending neurologist. All patients had an electroencephalogram, an echoencephalogram, brain scan, skull films and lumbar puncture. Localization of the lesion(s) and diagnosis was arrived at in the usual clinical fashion by synthesis of all available data. Pneumoencephalograms and arteriograms were used when indicated to confirm the diagnosis. Detailed memory evaluations were done on each patient by methods previously reported (4.) resulting in a memory profile report which simply catalogued the individual patients memory assets and defects.

Results

A. Patients with Left Hemisphere Lesions:

Fourteen patients with well localized left hemisphere damage were selected for inclusion in this report. The age range was 28 to 76 with an average of 52. There were 5 women and 9 men. Their diagnoses varied from stroke to glioma but in each case the localization of the lesion was proven by arteriogram, pneumoencephalogram, or operation, or by correlating the clinical exam with electroencephalographic abnormalities. The degree of memory defect bore no obvious relation to the intrahemispheric position of the lesion, nor did the severity of the memory defect correlate with the severity of the hemiparesis or other neurological signs. All patients had some kind of memory defect, probably indicating good selection on the part of the referring physicians. Distant memory was impaired in 6/14 cases and in 3 of these 6 the defect involved only distant events of an impersonal nature leaving distant events of a personal nature preserved.

All 14 patients had verbal recent memory defects whereas only 3/14 had visual memory defects. The three patients with left hemisphere lesions who showed some mild visual memory defect all had possible compromise of right hemisphere function. For instance, the large left frontal-temporal arteriovenous malformation of one case could be stealing blood from the right hemisphere. The left temporal glioma of another case could be exerting pressure and causing compromise or right hemisphere function, and the stroke of the remaining patient could reflect the predominant and most acute lesion in a brain actually involved diffusely.

The striking finding of a marked dissociation between poor recent memory for verbal material and good recent memory for visual items suggests that the dominant hemisphere is specialized for verbal memory in the same way that it is specialized for other verbally mediated tasks such as speech. Milner's work, although testing systems were different, yielded similar results (2.).

Gustatory memory was impaired in 4 of the 13 patients in whom it could be tested indicating this form of memory, under this type of testing, was quite stable compared to verbal recall. Olfactory memory was impaired in only one of the 14 cases.

The findings indicate that there are modality specific memory regions in man, and that a lesion in one part of the brain may influence one kind of memory more than another.

B. Patient with a Right Hemisphere Lesion:

A 48 year old man with a stroke involving the non-dominant hemisphere had marked defects in recall or recognition of impersonal memories, and in recognition of visual or olfactory test items after distraction. Of course, no firm conclusions can be drawn from this one case alone, but the findings of marked impairment of visual memory with preserved verbal is just the opposite of the findings in dominant hemisphere disease.

Detailed psychological testing of this type of patient has shown that they have visual memory defects (2.) but the practical, clinical importance of this finding has never been demonstrated. The paucity of patients with only right hemisphere pathology referred to the memory service is due to the fact that visual memory is relatively non-essential in everyday life, and patients with right hemisphere lesions are either satisfied with their preserved verbal memory or they and their physicians are unaware of the visual memory defect. Patients with right hemispheric lesions who were not referred for memory evaluation were not examined because it was not the aim of this study to pursue or duplicate pure psychological research that has already been done by competent psychologists.

C. Patients with Bihemispheric Disease:

Thirty-five patients are reported.. They were classified into three groups. Group I had bilateral cerebral atrophy demonstrated on pneumoencephalogram. Group II had low pressure hydrocephalus meeting all of the clinical and laboratory criteria

for that diagnosis as defined by Adams, Fisher, Hakim et al. (5.). Group III consisted of well defined bilateral cerebral disease in patients with tumors, head trauma, encephalitis, and strokes.

All patients had some kind of memory defect, and memory changes, especially in the atrophy and low pressure hydrocephalus groups, were among the earliest and most common feature in the initial presentation of the disease. Always memory for recent events was affected first and no case had distant recall impaired without also having some defect in recent memory. Among the recent memory modalities, verbal was most frequently defective being impaired in 19/20 or 95% of the Group I atrophy cases, 6/6 or 100% of Group II low pressure hydrocephalus cases, and 9/9 or 100% of Group III miscellaneous cases. Visual recent memory was involved in 16/20 or 80% of Group I, 6/6 or 100% of Group II, and 9/9 or 100% of Group III. Gustatory and olfactory modalities were also often defective. The actual pattern distribution of recent memory modality defects in individual patients was variable and probably reflected the pattern distribution of hemispheric pathology in each individual case.

Contrary to expectation, distant memory was normal in only 7/35 or 20% of the patients leaving 28/35 or 80% with marked impairment of distant memory for impersonal events. Only 12/35 or 34%, however, had impaired recall of distant events and memories of a personal nature. No patient had personal events impaired while impersonal memory for distant events was preserved. In other words, impaired distant memory for impersonal events was

required before impaired distant memory for personal events occurred.

Cerebral atrophy and diffuse cerebral dysfunction, therefore, tend to affect memory in a complex but predictable way. First, recent memory is impaired then remote memory is affected. When recent memory is impaired the verbal modality is affected most frequently followed by visual, gustatory, and olfactory. Of course, since modality specific memories are also dependent on the localization of the lesion, a pathological process affecting the non-dominant hemisphere, would be expected to affect the modalities (visual and ? olfactory) located in the non-dominant hemisphere with relative preservation of the modalities (verbal and ? gustatory) localized in the dominant hemisphere. If remote memory is affected, memories for impersonal events (like a world war) was affected before memories for personal events (like the birth of a child). Efficiency of distant recall is clearly dependent on the type of memory and its original emotional significance to the individual subject, and contrary to popular belief distant memory is often severely affected by brain disease.

The sum of the data confirms the impression that human memory is a complex brain function which is modality, duration, and lesion localization dependent. The presence of preserved modalities or relatively preserved modalities in brain damaged people indicates the possibility that the defective modality could be bypassed by attaching the to-be-remembered items onto the preserved modality thus bypassing the defective modality and

restoring apparent functioning. Since the main socially required correction in these patients is repair of verbal memory and learning, and since in most cases visual memory was preserved or relatively more preserved than verbal, the natural need would be for a visual method of remembering in order to bypass a verbal defect. The ancient art of memory seems to be one way of meeting such a need.

Part II. The Ancient Art of Memory and Mnemonic Systems

Very few people realize that the ancient Greeks and Romans, lacking books, file cabinets, tape recorders, photographs, and paper, had to rely heavily on their memories and used a system of mnemotechnics to augment the recall of specific information. Seneca, a teacher of rhetoric, for instance, could, by using these techniques, repeat two thousand names in the order in which they were given; and when a class of two hundred students or more spoke each in turn a line of poetry, he could recite all the lines in reverse order, beginning from the last one said and going right back to the first. And, St. Augustine, also trained as a teacher of rhetoric, tells of a friend called Simplecius who could recite Virgil backwards. Pointless though such feats may seem to us, they illustrate the respect accorded in antiquity to the man with the trained memory. The memory techniques used by these ancients are now known collectively as the ancient art of memory.

The ancient art of memory was invented by Simonides in 477 BC. According to Cicero in De Oratoria, Simonides had chanted a lyric poem at a banquet given by Scopas, a nobleman of Thessaly. Subsequently, while the poet was out of the room, the ceiling collapsed crushing Scopas and his guests. The corpses were mangled beyond identification. But Simonides, noting that it was through his memory of the places at which the guests had been seated, that he identified the bodies, realized that orderly arrangement is essential for good memory and that a visual image

of the to-be-remembered item is easy to recall. The Parian chronicle, a marble tablet of about 264 BC which was found at Paros in the 17th century, records legendary dates for discoveries like the invention of the flute, the introduction of corn, and the recitation of Orpheus' poetry. In historic times the tablet's emphasis is on the prizes awarded at festivals. The entry which confirms Cicero's attestation is as follows: "From the time when Simonides son of Leoprepes, the inventor of the system of memory-aids, won the chorus prize at Athens and the statues were set up to Harmodius and Aristogeiton, 213 years (ie. 477 BC)."

This art, whose history is recorded in an excellent book by Yates (6.) seeks to memorize by impressing images on places to facilitate recall. The methods are adequately described by Cicero and Quintillian but specific examples of its practical application can only be inferred from our present knowledge of similar systems used by comtemporary mnemonists. The extravagant claims made by commercial schools of memory run by men like Farst and Lorayne and others have only recently been subject to objective testing and analysis. The conclusions are that, when normal college students are used as subjects, recall of specific information can be increased enormously by use of such systems. It has been demonstrated, for instance, that capacity for serial learning and paired associate tasks can be increased at least an order of magnitude.

The author has studied most of the memory systems available at the present time and reviewed the history of this ancient art.

His own memory has been increased enormously and his memory, like that of Shereskevskii, the Russian mnemonist who used such systems, appears to have no clearly defined limits. Easily picturable concrete items can be recalled 90% to 100% correctly days after encoding and the author has, as a demonstration, memorized many lists of 50 unrelated items with excellent recall. Practice in making absurd visual associations has enabled him to encode items at the rate of one per eight to ten seconds. Less visual items and more abstract terms require mental conversion into visual items and therefore need more time for encoding. Using a special phonetic system in which numbers are converted to sounds, sounds to words, and words to images, it is possible to remember any number. On repeated occasions the author has as a demonstration and also as an aid in his everyday life, memorized 12 and 15 digit numbers quickly. Usually a 12 digit number will take 1½ minutes to encode, a 20 digit number takes three to four mintues. Since the number is actually stored as a meaningful concrete visual image and not as the intangible, meaningless item it really is, subsequent recall is easy. The extra effort needed to encode the item in this manner is amply repaid by the benefits of increased recall. It is not true, as Cicero correctly points out, that memory is crushed beneath a weight of images.

The crucial question raised by this investigation was whether or not such mnemonic systems could be utilized to augment the failing memories of patients suffering from organic diseases of the nervous system and whether or not such mnemonic

systems could be used to bypass specific defects in verbal learning.

This part discusses the methods which can be used to increase a patient's recall, gives two case illustrations, and outlines criteria for predicting which patients are likely to benefit the most from such treatment. The suggestion is that such mnemonic techniques may be the foundation of a new branch of rehabilitation therapy helping patients recover their memories and partially filling the therapeutic vacuum which now exists in this part of medicine.

Method

Mnemonic Techniques.--Systems outlined by Cicero, Quintillian, Furst, and Lorayne were adapted for patient use. Each patient was trained in forming vivid, visual images in his mind's eye and connecting these with the to-be-remembered items. The patient was told that all memory consists of associating what we want to remember with what we already know and that vivid, visual, ridiculous associations are remembered best. For instance, suppose one wants to remember the following shopping list: bread, carrots, eggs, dog food, newspaper, bacon, and deodorant. If we know bread and want to remember carrots we picture a giant loaf of bread breaking open and carrots falling out. The instructor would pause briefly to enable the patient to form the association picture and to "see it" in his mind's eye. Similarly, eggs are connected with carrots by picturing a chicken hatching a carrot. Dog food is connected with eggs by picturing a dozen

eggs running around the street on a leash. Newspaper was connected to dog food by seeing a dog reading a paper; bacon connected with newspaper by visualizing someone reading a bacon instead of a newspaper; and deodorant was connected with bacon by picturing someone putting bacon under their arms instead of deodorant. Care must be taken that at each step the patient forms his own visual image and sees it momentarily in his own mind's eye.

The patient was then distracted by some unrelated conversation and then retested sometime later by supplying the word bread. The recall of bread would bring to mind the carrots, the carrots, the eggs, and so on; each item was easily linked to the subsequent item via the ridiculous image. Recall was remarkably fast, easy, and enjoyable.

The same system was then applied to a 15 item list so that patients, encouraged by their seeming spectacular progress, would continue in treatment. Then patients were given a peg list of visual items to attach to the numbers one to ten and asked to memorize the peg list (Table) for the next session. Little mnemonics were given to facilitate memory but these are trivial and will be left to the reader's imagination.

Once the peg words were memorized, the patient was shown how the list could serve as a memory lable when any item is attached in a visual way with the peg item. The practical utility in memorizing shopping lists and organizing one's daily activities, was emphasized and illustrated. The patient also practiced

the use of the system by memorizing a list of ten unrelated items. The reader is urged to follow along now and form the visual associations suggested. The peg images and words will be supplied later, so don't worry about them. Here is your chance to prove to yourself whether or not this system has any usefulness in augmenting recall. The to-be-remembered list is as follows: 1, radio; 2, airplane; 3, lamp; 4, cigarette; 5, picture; 6, telephone; 7, chair; 8, horse, 9, diamond and; 10, watch.

Make the following visual associations, and most important try to see them for an instant in your mind's eye.

1. Connect teacup with radio by seeing yourself drinking from a radio instead of a cup.

2. Connect Noah with an airplane by seeing an old man and some animals in the pilot's cabin of the airplane.

3. Connect ma with lamp by seeing your mother holding a bulb in her mouth and the bulb is lighting up.

4. Connect rye with cigarette by seeing someone smoking a bottle of rye instead of a cigarette.

5. Connect policeman with picture by seeing a picture directing traffic.

6. Connect shoe with telephone using an absurd visual image you made up yourself. In the same way make the following connections. Be sure you make a visual image and be sure it is ridiculous, and be sure you "see" it for an instant in your own mind's eye.

7. Cow to chair. 8. Ivy to horse.

9. Pea to diamond. 10. Toes to watch.

Do not review the original list or your associations. That is not needed. In fact, focus your attention on something else for five minutes and dismiss the list from your mind. Then return to the peg words in the Table to see how many items can be recalled. What did you associate with teacup? With Noah? With ma? The average patient gets all items correct in or out of sequence. Usually the recall sequence starts with the number, the number is linked to the peg word, and the peg word to the peg image. As soon as the peg image flashes before the slate of consciousness the ridiculous visual image is thought of and the item to be recalled is retrieved eg, the patient would think 3 was Ma. He would see a picture of his mother and then the burning bulb in her mouth would recall the test item associated with 3 was lamp. Errors of omission are usually due to poor visualization of the original association and failures of recall are due to failure to make the visualization ridiculous enough. False recall is seen only when patients try to bypass the visual system and recall the item from their natural memories. Evidently, from the success and facility of this system, we may conclude with certainty that thoughts or mental activity, once having formed the same total thought, tend ever after immediately to suggest each other.

At this point in the patient's progress he is taught how to connect numbers into words and words into numbers, and additional peg words from 11 to 100 are logically derived from the conversion principles. An assignment to memorize the US presidents is easily carried out and the successful patients are

usually showing off their memory skill before friends and family.

Report of Cases

Case 1.--This pharmacist was well until age 60 when he developed a transient attack of drooping of the right side of the face and decreased vision in the left eye. He was admitted to another hospital and observed for ten days. Subsequently, he was well until age 62, when he awoke with severe substernal pressing chest pain and mild nausea. Physical examination was normal but electrocardiogram showed Q waves in V_1 to V_5. Chest x-ray film demonstrated an enlarged heart and serial enzyme elevation confirmed the clinical diagnosis of myocardial infarction. On the fifth hospital day, the patient became aphasic and hemiphlegic on the right. Neurological examination showed a right field cut, expressive aphasia, right heimphlegia, right-sided areflexia, and a right Babinski sign. Over the ensuing two months the patient's aphasia cleared somewhat, and he was able to say simple words. Complex words could not be pronounced, and he frequently could not name objects even though he correctly picked the names from a list. The Wechsler Adult Intelligence Scale indicated a verbal intelligence quotient of 102 and performance IQ of 99. Bender-Gestalt, in the opinion of the psychologist, showed no perceptual problems but did indicate confused recall. The psychologist felt the patient was incapable of learning since he demonstrated no recall of any recent information.

One and one half years later, the patient was referred

for memory evaluation. At that time the patient did not know the day, date, or month. He gave the year and place correctly. His distant memory for personal events was normal but recall of distant impersonal events was defective because he could remember only four drugs of the thousands he once knew as a pharmacist, and he could not remember any events of World War II. He did seven digits forward, but only two backwards, and he recalled none of three unrelated verbal items after distraction. Clues, cues, and lists did not improve his verbal performance. Visual recognition memory, by contrast, was good, and he recognized three of three face pictures after distraction. Recognition memory for smells was normal. Taste memory could not be tested because the patient had been unable to taste since his stroke. It was reasoned that this patient's selective verbal memory impairment with preserved visual memory was due to dysfunction of the dominant hemisphere, a finding noted by others. If a system could be used to augment verbal recall then his performance might be increased enormously. Six months later, the author ran across such a system when he read a course on memory by Furst. The patient was then brought back and retested. His verbal memory, orientation, and dysphasia were the same.

Memory Therapy.--This patient was taught how to make vivid, visual, ridiculous associations. He quickly realized that he was able to enormously augment his verbal recall. After one week of practice he was able to recall the days of the week

and two of three unrelated verbal items after distraction. He did four digits backwards instead of the previous two. The second week of therapy he could recall correctly four of five unrelated items after distraction and had memorized the peg list from 1 to 10. His digit span was now 7 forward and five digits backward. The third week of therapy his performance was markedly worse. Although completely oriented, he was now unable to recall any of seven unrelated items. The reason for the poor performance was that, having become over confident about his memory, he had failed to make any visual associations. After the realization that the ridiculous pictures are essential, he returned the next week and successfully recalled 15 of 15 unrelated items after ten minutes of distraction. At this time he had noticed that his natural memory was also improving so that he now easily recalled his social security number. For some unknown reason, his expressive dysphasia was improved. He was now able to clearly say words like zipper, respectable, and Kennedy which he had not been able to say before. As an exercise, he memorized the presidents of the United States from 1 to 37 by attaching visual images to the peg words supplied. For instance, the peg for 14 is tire. If the patient was asked who was the 14th President, a visual image of a tire with an arrow in it would flash before his mind. "Seeing" the arrow would recall Pierce. The peg word for 19 is tub. If the patient was asked who the 19th President was, he would see a tub filled with hay which would, of course, recall Rutherford Hayes, our 19th President. This man was taught peg

words to 100 and how to use such combinations of peg words to recall numbers. His wife now uses his memory to recall shopping lists and appointments, and he is showing off his memory skills to friends and relatives.

Case 2.--This 37-year-old movie executive was admitted for evaluation of 18 hours of headache, confused speech, poor comprehension, and weakness of the right side of his body. Except for a temperature of 102 F (38.9 C), results of his general physical examination were normal. On neurological examination, he had a Wernicke type aphasia and confusion. The patient ignored the right side of his body. There was a right homonymous hemianopsia, weakness of right lateral gaze, right central facial paresis, and right hemiparesis. Sensation to all modalities was absent to markedly decreased on the right side. Routine blood studies were normal except for a white blood cell count of 13,700/cu mm, with 85% neutrophils. Echoencephalogram showed a 4 to 5 mm left to right shift, brain scan had a left temporal uptake, EEG demonstrated a left fronto-temporal slow wave focus, and left carotid arteriogram was read as showing an avascular mass. At craniotomy, a large mass consisting of edematous brain was removed. Pathological diagnosis was herpes simplex encephalitis and idoxuridine therapy was begun. The postoperative course was complicated by continuous fever for 12 days, a subgaleal infection, and hepatitis. Subsequently, the patient slowly improved and was discharged with a marked speech deficit mild hemiparesis, and a right homonymous hemianopsia.

Over the ensuing months his aphasia cleared, but the patient continued to complain of major difficulty remembering verbal material especially names, telephone numbers, and the things people said to him. He also noted that, if distracted, he would quickly forget the trend of his own thoughts. Because of these problems, seven months after operation, he was referred for memory evaluation. At that time he was completely oriented and was able to read and write. He named objects well, repeated words and phrases, obeyed commands, and seemingly had little aphasia or apraxia. He knew the details of his own biography including his birthday, home address, telephone number, fifth grade teacher's name, etc. The events and leaders of World War II were quickly and reliably recalled. He could do seven digits forward but only four backward. He recalled only one of three unrelated verbal items after distraction. Lists but not cues or clues helped to facilitate recall. Visual, olfactory, and gustatory memory were normal. Of interest, this patient had noted an increase in his ability to remember faces and other visual material since his operation. He also reported a new power to mentally revisualize in his mind's eye things he had seen before, a skill not present prior to his illness. The remarkable preservation of his visual memory was used as therapy to increase his verbal recall. The verbal to-be-remembered items were simply converted into images and stored in the visual modality and then subsequently revisualized and converted into words. For instance, if he wanted to remember the five principal industries of Venezuela, he pictured in his mind's

eye a miner, driving a tractor. In one hand the miner had a fishing pole, in the other a lamb. The whole tractor was being pushed upward by a gusher of oil. When recall was needed he merely pictured the scene. The miner reminded him of mining, the lamb of animal husbandry, the fishing pole of fishing, the tractor of farming, the oil of petroleum production. Similarly, he was able to augment his English language vocabulary by visualizing the meaning of the word or associating in some way the meaning of the word to a visual image. For instance, his disease had erased the meaning of the word piebald. Endless efforts to memorize the meaning verbally were ineffective but by seeing in his mind's eye a bald pie with black and white patterns the meaning of the word would quickly flash before his stream of consciousness. Using this technique he was able to add 10 to 25 words to his English language vocabulary each day.

Each of the cases in which memory therapy was successful was able to overcome a verbal memory defect by the strategy of encoding in the preserved, or relatively preserved visual modality. Naturally, low intelligence, poor motivation, and poor imagination interfere with the application of the mnemonic system. The patients responding to therapy benefit in proportion to their skill in using the system. In general, benefits are easily perceived by patient and doctor in the first lesson. The practical application of these systems to the patient's everyday life is not proved. But, the patients reported here have found that they are now relying on their own memory skills rather than on those of others. The benefit from a marked increase in self-esteem

that comes from being able to show off memory skills to relatives and friends should not be underestimated. Self-esteem is important in altering the mental set of these usually depressed patients, and substantial progress in memory has caused a change in the patient's outlook on life. The improvement in the first patient's expressive dysphasia was unexpected and is unexplained, but could have been a side effect of the treatment.

Since visual images can be mentally manipulated just as verbal thoughts can be mentally manipulated, the question arises as to whether or not visual thinking might be helpful in promoting creative thinking. The next part illustrates this possibility.

Table I

Sample List of Memory Pegs and Images

Number	Peg Word	Ped Picture
1	Tea	Tea cup
2	Noah	Old man in ark
3	Ma	My mother
4	Rye	A bottle of rye
5	Law	Policeman
6	Shoe	A shoe
7	Cow	Someone milking a cow
8	Ivy	College wall covered with ivy
9	Pea	Giant pod filled with peas
10	Toes	A foot with toes on it

Part III. Report of the case of Albert Einstein

The third part of this paper discusses the case of Albert Einstein and illustrates how someone with a defect in the verbal modality can overcome the defect by using visual methods of thinking.

Report of A Case

Details of the patient's early history are lacking, but as far as is known Albert Einstein was the product of a full-term, normal pregnancy and delivery. At birth his mother considered the child's head too large and angular, but in spite of the deformity her doctor said the child would grow well (7.). Early motor development was normal. Verbal development was delayed for Einstein did not speak until age 3 (8.). His sister Maja (9.) reports, in her unpublished biography, that his searching for words was laborious and each spoken sentence, no matter now commonplace, was repeated silently with his lips, a practice he was finally able to abandon at age 7. There is no evidence that the child had any trouble eating, chewing, swallowing, or phonating and, although he did not freely associate with his peers, he did have a close and warm relationship with his mother and sister. It seems reasonable, therefore, to tentatively assign the delayed verbal development to some sort of aphasia rather than aphonia or childhood autism.

School work did not go well for young Einstein. Because he had little facility with arithmetic, no special ability in any other academic subject, and great difficulty with foreign language, his teacher predicted that "nothing good" would come

of the boy (7.). Poor performance was not the result of lack of application for he applied himself carefully and diligently, persevering in attempts to do his arithmetic homework, but more often than not coming up with the wrong answers.

Perhaps it was the frustration of trying so hard and achieving so little that explains his behavioral abnormalities, for he was quick to anger and often violent. Once, at age 5, after he had begun home tutoring and violin lessons, he became so furious at his teacher that he threw a chair at her and gave her such a fright that she refused to see the boy again. In another quarrel, he hurled a heavy bowling ball at his sister, and once, she reports, he tried "to knock a hole in her head" with a trowel (9.). While such acts may not exceed the normal aggressiveness of young boys, it should be noted that behavioral disorders of this type are quite common in the dyslectic and these behavioral problems are a common cause for referral of dyslexic children. With improvement of the learning problem the behavioral disorder usually disappears, and a seeming change in personality toward gentleness and niceness usually occurs. The striking contrast of Einstein's poor behavior as a frustrated child with his remarkable gentleness and sensitivity as an adult suggests that the bad behavior was conditioned by his frustrations, not by his constitution. As his unique skills were recognized and he achieved his distinction as a scientist, the adjustment problems lifted and his behavior changed for the better.

Einstein's verbal disabilities persisted in large part into adult life and he once remarked to R. S. Shankland, "When I read I hear the words. Writing is difficult, and I communicate this way very badly" (10.).

In sharp contrast to his trouble with verbal realms were his abilities in nonverbal spheres of activity. Even before age 10 he was well-known for his construction of intricate and colossal playing-card houses, some of them 14 stories high. Many hours were spent building these card houses and one can only imagine the patience, precision, and thoroughness required, as well as the feeling for spatial relations, balance, and symmetry probably learned in the process. He often completed large jigsaw puzzles, and spent a lot of time constructing buildings from prefabricated blocks.

The extracurricular study of geometry was a special inspiration. Jakob Einstein, his uncle and a successful engineer, challenged the boy with geometrical puzzles. When Uncle Jakob demonstrated the Pythagorean Theorem - the sum of the squares of the two sides of a right triangle equals the square of the hypotenuse - Einstein thought the Theorem obviously true from mere visual inspection and in no need of proof. He reasoned this from seeing that "the acute angle determines the sides" (8.). Nevertheless, before age 10 he proved the Theorem by a method of his own based on similarities of triangles. This demonstration was different from the orthodox proof, and was probably the first indication that the boy was a creative thinker.

Unfortunately, the school at Munich where he did his early studies was word oriented and not equipped practically or

philosophically to uncover or develop these early constructive and visual talents. Learning there was largely by rote. Conceivably Einstein would have languished forever had he not left that regimented place at age 15* and enrolled in the Kanton School at Aarau 30 miles northwest of Zurich. There is no doubt that this was a fundamental turning point in his life. Aarau school was founded by Pestalozzi, a Swiss educational reformer, who published in 1801 his ideas on visual methods of learning and teaching. Basic to Pestalozzi's approach was the view that "conceptual thinking is built on visual understanding; visual understanding is the basis of all knowledge." An excerpt from his book gives an idea of the approach followed in the schools founded under Pestalozzi's influence:

> I must point out that the ABC of visual understanding is the essential and the only true means of teaching how to judge the shape of all things correctly. Even so, this principle is totally neglected up to now, to the extent of being unknown; whereas hundreds of such means are available for the teaching of numbers and language. This lack of instructional means for the study of visual form should not be viewed as a gap in the very education of human knowledge. It is a gap in the very foundation of all knowledge at a point to which the learning of numbers and language

*In fact Einstein was probably expelled (11.).

> must be subordinated. My ABC of visual understanding is designed to remedy this fundamental deficiency of instruction (12.).

Pestalozzi had a wide influence in those days and even Von Humboldt and Talleyrand visited him and his schools. He freely used maps, diagrams, and other visual materials for instruction. The atmosphere was relaxed and informal. Memorization was discouraged and individual thinking was developed. Each item of learning was carefully linked to a visual base image in accordance with principles described.

At last Einstein flourished in a situation which did not impair the free expression of the particular styles of thinking that were so congenial to him. With the recent organization and partial publication of the Einstein papers, the evidence that this style of thinking was nonverbal and visually mediated cannot be doubted.

Max Wertheimer, a psychologist friend of Einstein, had many opportunities to question the physicist on the concrete events in his thinking process leading to the relativity theory. Einstein told him: "Thoughts did not come in any verbal formulation. I very rarely think in words at all. A thought comes, and I may try to express it in words afterwards" (13.).

Responding to Jacques Hadamard, Einstein again provided an insight into his thought process:

> Words or language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be voluntarily reproduced and combined. . . This combinatory play seems to be the essential feature in productive thought - before there is any connection with logical construction in words or other kinds of signs which can be communicated to others. . . Conventional words or other signs have to be sought for laboriously only in a second stage, when the mentioned associative play is sufficiently established and can be reproduced at will (14.).

Again in his autobiographical notes Einstein emphasized the nonverbal nature of his thought process:

> What, precisely, is "thinking"? When at the reception of sense-impressions, memory pictures emerge, this is not yet "thinking." And when such pictures form series, each member of which calls forth another, this, too, is not yet "thinking." When, however, a certain picture turns up in many such series then - precisely though such return - it becomes an ordering element for such series, in that it connects series which in themselves are unconnected. . . For me it is not dubious that our thinking goes on for

the most part without use of words (15.).

On reading Relativity, the Special and General Theory, Einstein's popular book about the origins, implications, and complications of thinking about fundamentals one is impressed by the awkward simplicity and redundancy of Einstein's use of language - especially when contrasted with the splendid visual images he leads us to manipulate in our mind's eye so that we can discover physical truths ourselves. The interested reader is urged to consult the book for details. Picturesque thought experiments involving watch readings, light signals, mirrors, positions of locomotives, and lightning are found in abundance. One's understanding of relativity is totally dependent on being able to imagine vividly some thought experiments using mirrors, locomotives, and lightning, and involving the perceptions and reports of two observers moving relative to each other. The style of thinking is completely different from that required in developing a logical, verbal formalism.

The truth is obvious - once satisfactory visual images have been mentally established and manipulated. For example, in considering gravity, Einstein asks the reader to imagine a large cage positioned in space. A man is in the cage and the cage is being pulled upward by a large hook at a uniformly accelerating rate. If the man were to let go of a ball in the cage, the ball would appear to fall to the floor and the man in the cage would perceive the fall as the result of a gravitational field operating to accelerate the ball downward. Another observer,

looking at the hook from another coordinate system and seeing that the cage was being accelerated upward would see the ball remaining still in space, because of its inertia, and the floor of the cage merely moving up to meet it. Thus, in one clear, crisp, clean visual thought experiment does Einstein show us that a so-called gravitational field can be understood in terms of inertia and uniform acceleration. Of course the corollaries of this visual system of thinking include an esthetic respect for elegance, simplicity, and symmetry. These considerations plus a distaste for extraneous complexity contribute to the importance and power of Einstein's concepts. Visual thinking also allowed him to scent out whatever was able to lead to fundamentals, and to turn aside everything else that was cluttering the mind and diverting it from the essentials.

After completing his work at the Aarau school Einstein was admitted to the Polytechnical Institute at Zurich. After four years at the "Poly," unable to obtain an academic job even teaching high school, he took a position at the Patent Office in Berne. It was there, working in his spare time, that he published in 1905 the four papers that revolutionized modern physics: the special theory of relativity, the mass energy equivalence, the theory of Brownian movement, and the photon theory of light including work on the photo-electric effect. His subsequent fame and sojourn at the Institute for Advanced Study in Princeton are well-known. Details of the rest of his life are not relevant to this paper but can be found in Professor Einstein's own "Autobiographical Notes"

(15.) and Clark's excellent biography (11.).

Thus, it seems clear from the record that at least one scientific genius was able to overcome a handicap by circumventing the verbal modality in which he was deficient, achieving greatness through an unusual way of visual thinking. Intuitively, a person knows that when one drives a car, flies a plane, or estimates the trajectory of a baseball in order to catch it, words have little to do with the mental processes that animate success in these activities. In other words, there can be more to success than merely mastering facility with words.

In summary, the data presented here suggest that human memory and thought are extremely complex things which are duration, modality, and brain function dependent processes. It is possible by using unusual modalities and specific visual strategies for remembering and for problem solving to achieve great success. We must keep this in mind in our educational systems so that non-verbal and other unusual thought processes can be used to increase the potential of human thought. Our present verbally oriented educational system should not prevent geniuses in visual (and other forms of) thinking from achieving their full potential. The total thinking power of the average person's brain also, by this reasoning, remains to be fully exploited.

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